Fermi National Accelerator Laboratory

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Inclusive Jet Cross Sections and Jet Shapes at CDF

The CDF Collaboration

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ABSTRACT

The inclusive jet cross section and jet shapes at $\sqrt{s} = 1.8$ TeV have been measured by CDF at the Fermilab Tevatron Collider. Results are compared to recent next-to-leading order QCD calculations, which predict variation of the cross section with cone size, as well as variation of the jet shape with energy. A lower limit on the parameter Λ_c, which characterize a contact interaction associated with quark sub-structure is determined to be 1400 GeV at the 95% confidence level.

1. Introduction

CDF has collected approximately 4.2 pb^{-1} of integrated luminosity at $\sqrt{s} = 1800$ GeV of $p\bar{p}$ collisions. This high statistics sample allows more accurate tests of QCD. Fortunately, significant theoretical progress is being made in parallel, and Next to Leading Order (NLO) calculations[1] are now available.

2. Data Selection

The CDF detector has been described in detail elsewhere.[2] For these measurements, jets in the central calorimeter, in the pseudorapidity range $0.1 < |\eta| < 0.7$, were used. The jet shapes distribution was obtained from three dimensional tracks measured in the central tracking chamber.

For these analysis, 3.9 pb^{-1} of data were used, triggered by single jet triggers which require the transverse energy of clusters in the calorimeter to be above specific threshold The minimum energy required were 20, 40 and 60 GeV. The 20 and 40 GeV triggers were pre-scaled, in order to maintain a manageable trigger rate.

Offline a cone cluster algorithm[3] was applied.The algorithm defines jets in terms of transverse energy (E_t) and cone size R, where $R = \sqrt{\Delta\eta^2 + \Delta\phi^2}$, η is pseudorapidity and ϕ is the azimuthal angle.

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3. The Inclusive Jet Cross Section

The inclusive cross section $d\sigma/dE_t$ was measured by averaging $d\sigma^2/dE_t d\eta$ over the range $0.1 < |\eta| < 0.7$. The results are shown in Fig. 1. for $30 < E_t < 420$ GeV and for a cone of 0.7. Given the 21% normalization uncertainty all NLO structure functions describe the data relatively well with the NLO calculation of reference 1. In Fig. 2. we show the dependence of the cross section on cone size R for E_t of 100 GeV. This effect, as well as the jet shape, is more dependent on the normalization scale μ as it is an exclusive α_s^3 process, not present in leading order calculations.

The corrected distribution was extracted by assuming a function for the original distribution. Then, all known detector effects were applied to the function to obtain a smeared function. This curve was fitted to the measured distribution. The parameters of the original function where changed iteratively, until a good agreement was found. The measured distribution was corrected by factors derived from the difference between the original and smeared function. The main source of systematic error is the uncertainty on the jet response in the calorimeter. The total systematic error ranges from 50% at low energy to 22% at higher energies for a cone of 0.7.

The limit on the parameter $\Lambda_c{}^*$ is derived to be 1.4 TeV.

4. Jet Shapes

Within the framework of NLO QCD calculations, it is possible to obtain more than one parton inside the cone, producing an energy distribution inside the jet cone.[4]

Tracks were used, to study the jet shapes, due to their better spacial and momentum resolution for single particles. The shape is defined by the average P_t density $\rho(r) = \frac{1}{N}\sum_{jets}\frac{1}{P_t^{jet}(R_0)}\sum_r dP_t$, dP_t is the P_t measured in the annular domain between r and $r+dr$. By definition $\int_0^{R_0}\rho(r)dr = 1$, so that P_t^{jet} is also calculated with the tracks. The integral shape variable $\Psi(r) = \int_0^r \rho(r')dr'$ is used to compare data with theory. The results are shown in Fig. 3. together with the definition of the variables for 100 GeV jets ($95 < E_t < 120$ GeV). The distribution was corrected for tracking efficiency effects.

In Fig. 4. we show the evolution of $\Psi(0.4)$ with jet E_t. The data shown were corrected also for the resolution in the jet axis determination.

The theory describe the shape surprisingly well, although being it is low by approximately 6% in the energy evolution of the shape.

References

1. S.D. Ellis, Z. Kunst and D.E. Soper, *Phys. Rev. Lett* **62** (1989) 726, and **64** (1990) 2121.
2. Abe et al., CDF Collab., *Nucl. Instr. Meth.* **A271** (1988) 387.
3. Abe et al., CDF Collab., *Phys. Rev. Lett* **62** (1989) 613.

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*Λ_c is defined by the coupling $\pm 2\pi/\Lambda_c^2$ on the four Fermi term added to the QCD lagrangian.

4. S.D. Ellis, private communication, based on ref. 1.

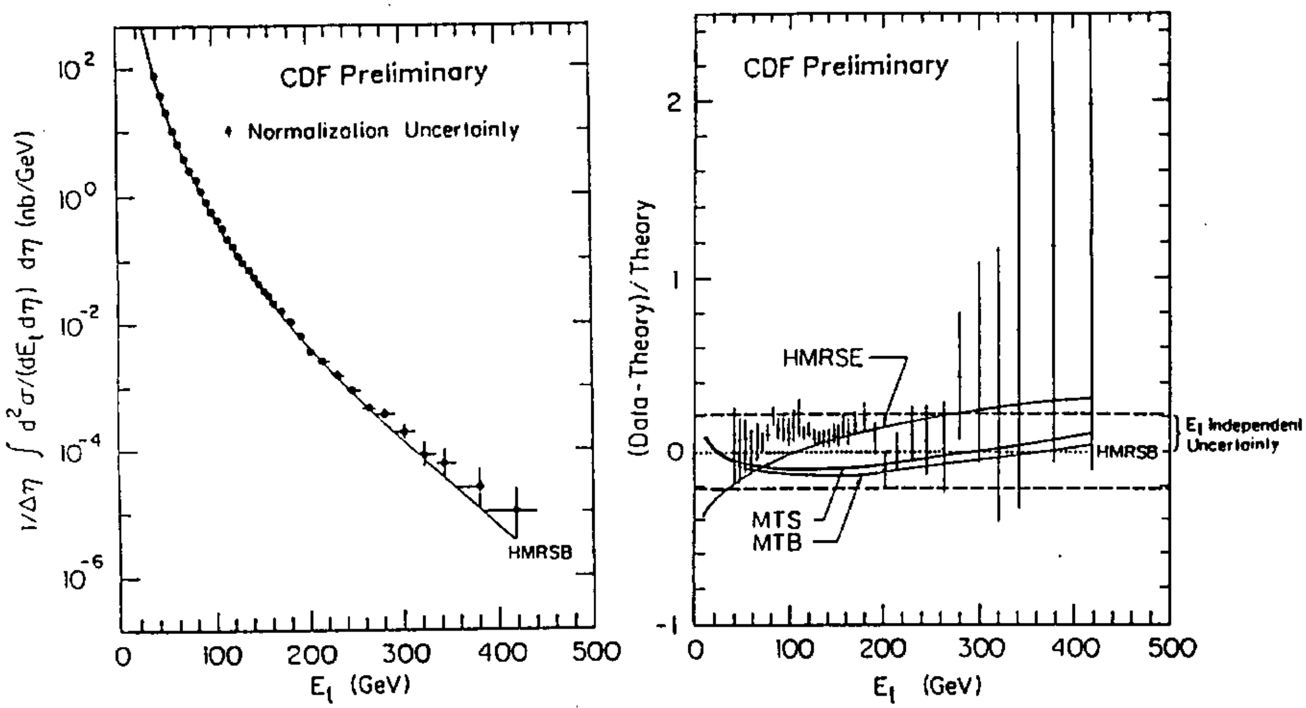

Fig. 1. The inclusive jet cross section.

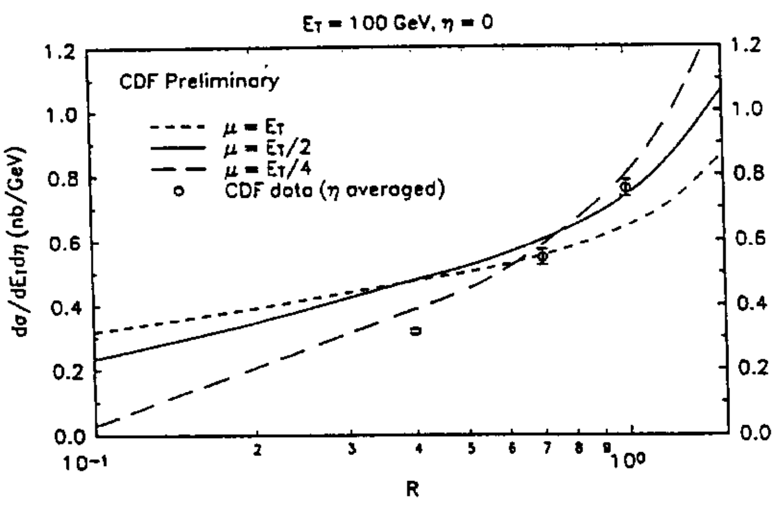

Fig. 2. Variation of the cross section with cone size, for 100 GeV jets.

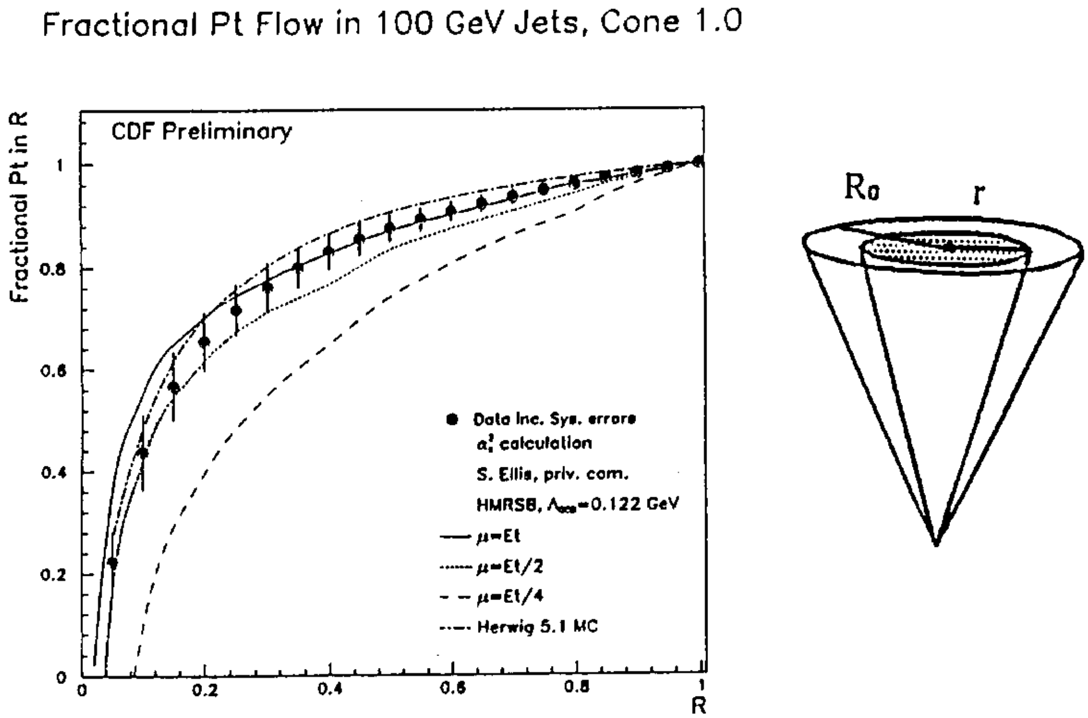

Fig. 3. Variables and the integral shape of 100 GeV jets.

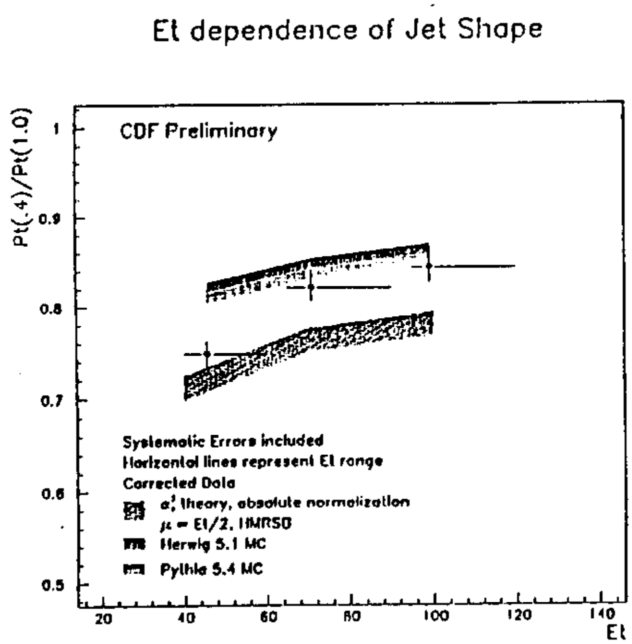

Fig. 4. Variation of the jet shape with jet E_t.